

# **SOME TOOLING FOR MANUFACTURING RESEARCH REACTOR FUEL PLATES**

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## **ABSTRACT**

This paper will discuss some of the tooling necessary to manufacture aluminum-based research reactor fuel plates. Most of this tooling is intended for use in a high-production facility. Some of the tools shown have manufactured more than 150,000 pieces. The only maintenance has been sharpening. With careful design, tools can be made to accommodate the manufacture of several different fuel elements, thus, reducing tooling costs and maintaining tools that the operators are trained to use. An important feature is to design the tools using materials with good lasting quality. Good tools can increase return on investment.

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## **INTRODUCTION**

This paper will discuss some of the tooling necessary to manufacture aluminum-based research reactor fuel plates. Most of this tooling is intended for use in a high-production facility. Some of the tools shown have manufactured more than 150,000 pieces. The only maintenance has been sharpening. The flow sheet used for manufacturing a fuel element is shown in Figure 1.

## **MANUFACTURING TOOLS**

The aluminum powder is vacuum degassed before use. Figure 2 shows the degassing tray and loader. The tray has separators because at the vacuum annealing temperature (500°C) there is a slight exothermic reaction. These separators reduce the volume so that aluminum caking does not occur.

The aluminum powder is stored under vacuum to keep it dry. The vacuum storage is shown in Fig. 3. Before use, the powder is sieved through a 100-mesh screen for 4 minutes at approximately 50% relative humidity to reintroduce the desired amount of moisture for good workability.

A 4-ounce glass jar holds the aluminum powder plus the fuel form and uses a 58-mm cap (see Fig. 4). The cap is metal—the gasket and paint are removed. The cap is chromium electroplated and uses a 1/16-in. neoprene gasket and a 0.010-in. aluminum cover over the neoprene (see Fig. 5). This is done to eliminate the cap lubricant and gasket material which may contaminate the powder charge.

The powder die, die tops, and punches are shown in Fig. 6. The inner portions of the die and punches are made of AISI type D-2 tool steel hardened to R.C. 58-60. The restraining ring around the tool steel in the die is 4240 hardened to R.C. 28-32. This restraining ring has a compression fit onto the tool steel equivalent to 22.5 tons/in<sup>2</sup>, which is approximately the pressing pressure of the compacts.

The die base is standard purchase. The die punch jack is a fabricated item and is designed to raise and lower the bottom punch. The punch is raised to level the powders. When the powders are leveled, the bottom punch is lowered until the powder charge is in the center of the die cavity. At this point, the jack table must be in its bottom position to prevent the table and table stem from breaking during pressing.

Figure 7 shows the die being forced down on the spring-loaded top of the die base to eject the compact.

The frame, cover, and compact are shown in Fig. 8. The frames are blanked. The blanking die is shown in Fig. 9. The frame is inserted into a cavity and is positioned against a plug. The air cylinder is energized holding the frame blank in place. The two ends and two cavities are blanked at the same time to assure that the two cavity faces and the ends of the frame are parallel. The cover plate is blanked in a similar fashion.

The tongs shown in Fig. 10 are set up to accommodate the fuel plate core. This tong makes it unnecessary to handle the compact by hand after vacuum annealing the compact, eliminating the possibilities of contamination from rubber gloves.

The frame loading requires a clean area, but not necessarily a clean room. Figure 11 shows the frame loading area with a plastic hood over the loading table to keep dust from collecting on the components.

The hot rolling mill has roll guides (see Fig. 12) to keep the billet straight to prevent trapezoid cores. The tongs have a block on the bite to prevent gripping too far onto the billet, preventing rejects due to scratches over the finished fuel plate.

Figure 13 shows the opposite side of the hot rolling mill. The gloves worn by the catcher are chain mesh, much like butchers use with two pair of heavy cotton gloves underneath.

Up to this point, we have been hot rolling two plates at once. After the sixth pass, the fuel plates have reached the maximum length for the furnace and must be separated after the seventh pass. Figure 14 shows the shears for separating the two fuel plates.

The fluoroscope (see Fig. 15) is an excellent tool for laying out the fuel plate core in the as-rolled fuel plate. The template for identifying the core (see Fig. 16) uses tungsten wires to identify the maximum and minimum core outline. When the core is located, two holes are punched in the plate outside the finished fuel plate. These holes are used to locate the core in the blanking die (see Fig. 17). If enough fuel plates are being made of a given size, the blanking die is most cost effective and accurate. All cutting surfaces on the blanking die are AISI type D-2 tool steel.

The plate forming die is shown in Fig. 18. The punch is designed to accommodate a spring back. Since a form other than a radius complicates the fuel element assembly greatly, the finished form of every fuel plate must be as close to the same as possible – plate to plate. The polyurethane elastomer is made up of two pieces: one 1¾ in. thick and the top, or waster, sheet ¼ in. thick. This combination has a life expectancy so long that its useful life has not been determined. The die may form fuel plates with a saddle. If this happens, a ½-in. by 3-in. steel insert is put at each end under the polyurethane. This will increase the pressing pressure on the ends of the fuel plate and reduce or eliminate the saddle.

Several tools for fuel plate manufacture have been shown. Obviously, there are many more. The intent has been to document all of the tools possible in a single report to prevent their loss and to provide a ready reference for the manufacturer.



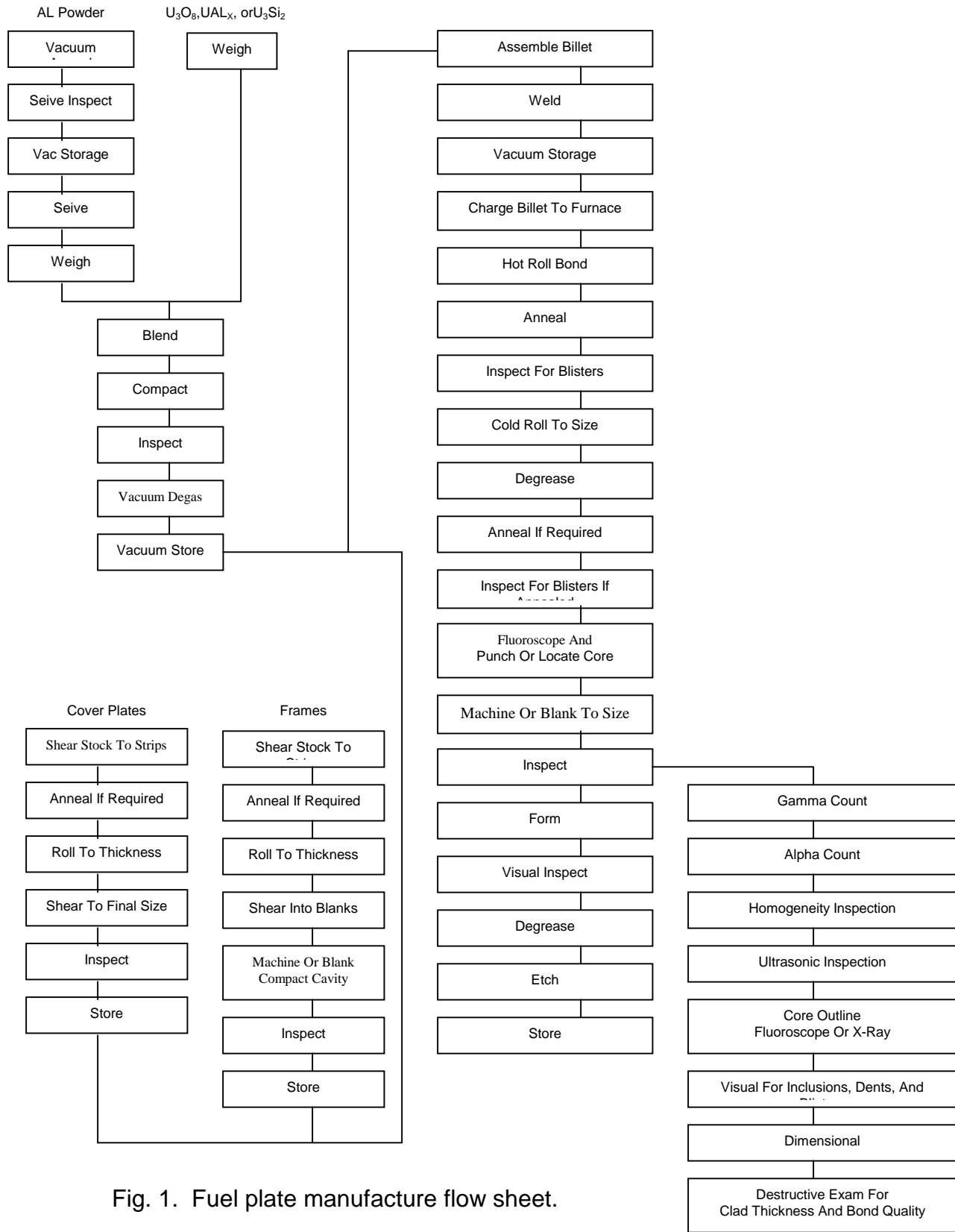


Fig. 1. Fuel plate manufacture flow sheet.

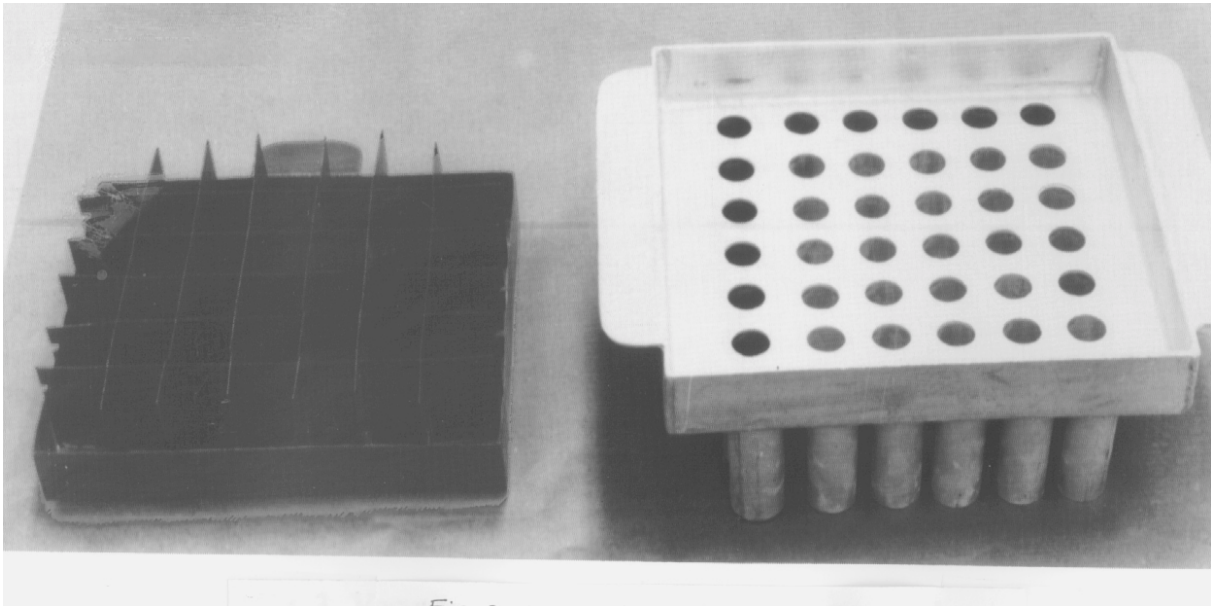


Fig. 2. Aluminum powder pan and loading fixture for vacuum annealing.



Fig. 3. Vacuum storage of aluminum powder.



Fig. 4. Charge jars of individual compacts.

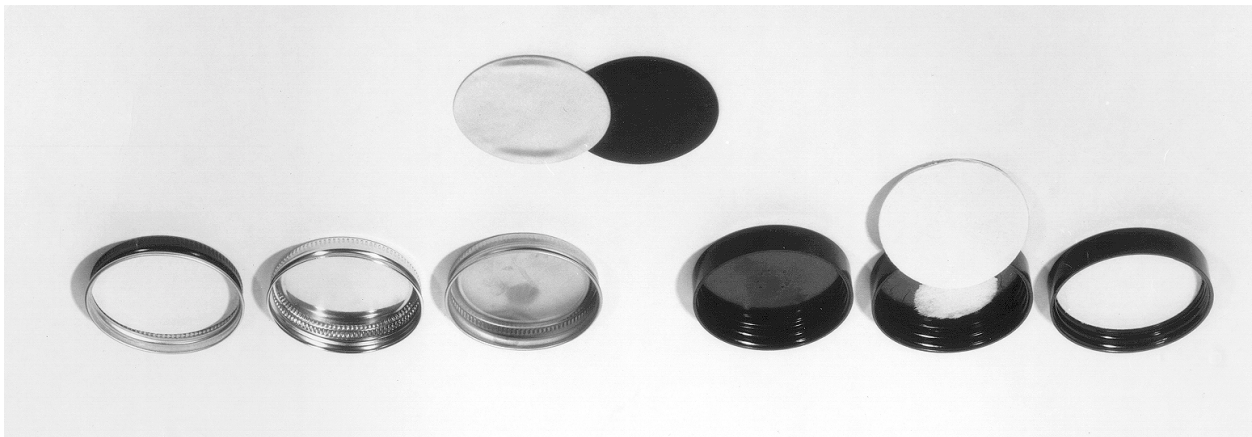


Fig. 5. Special jar caps for charge jars.

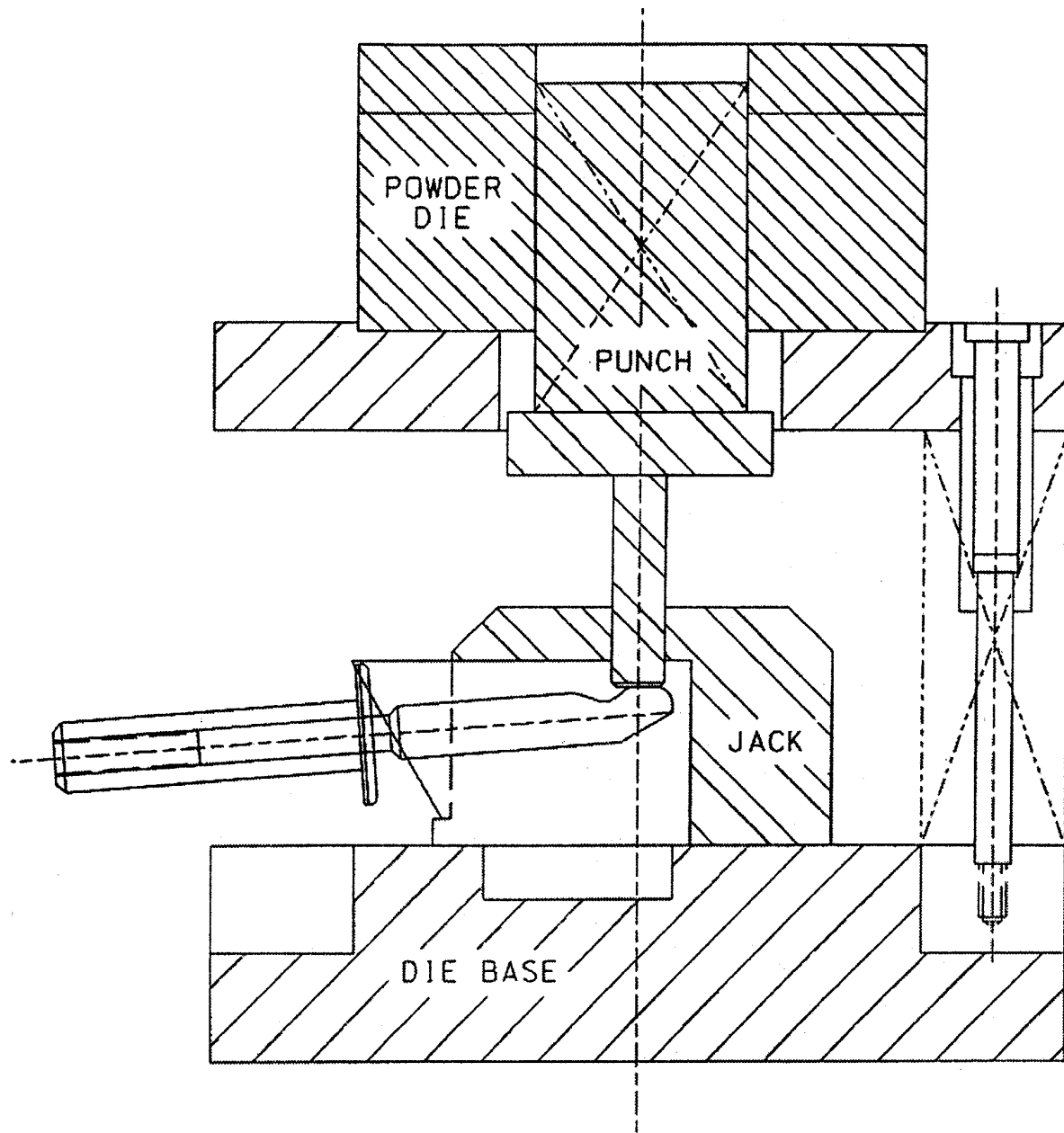


Fig. 6. Powder die, die base, and jack.



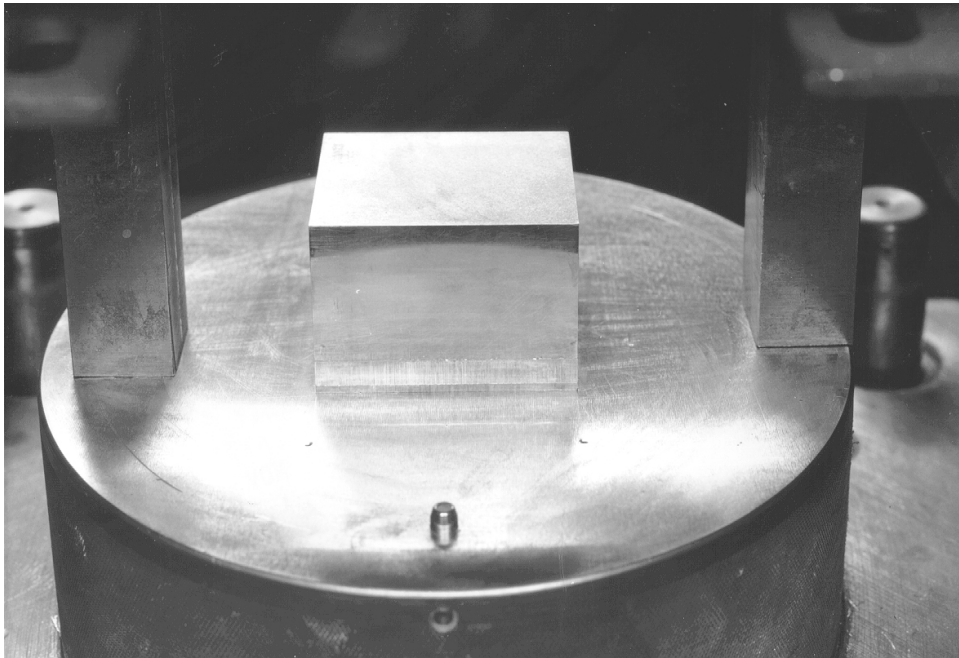


Fig.7. Compact being ejected from the die.

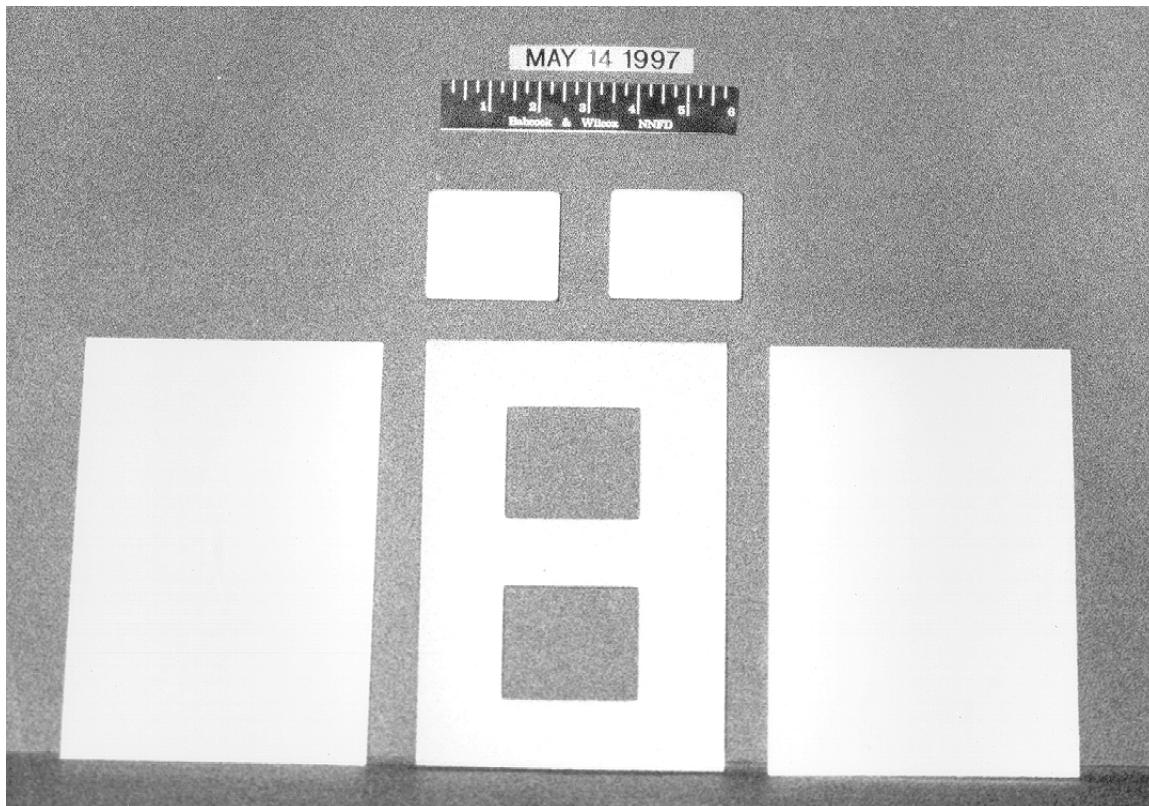


Fig. 8. Frame, cover plate, and compact ready for assembly.

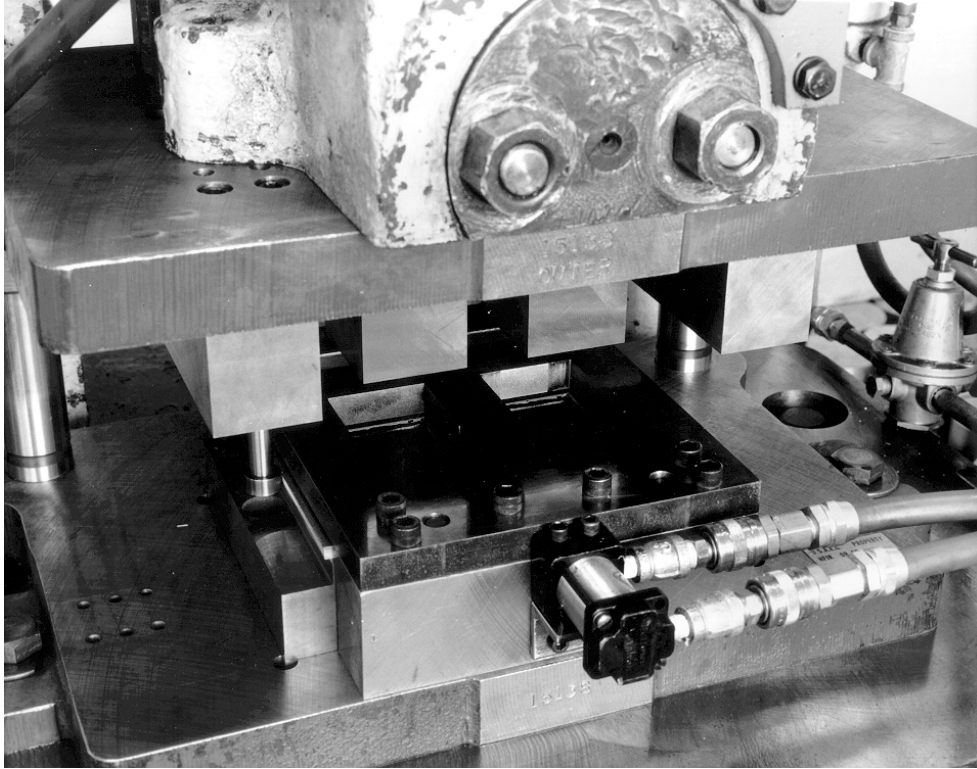


Fig. 9. Frame blanking die.

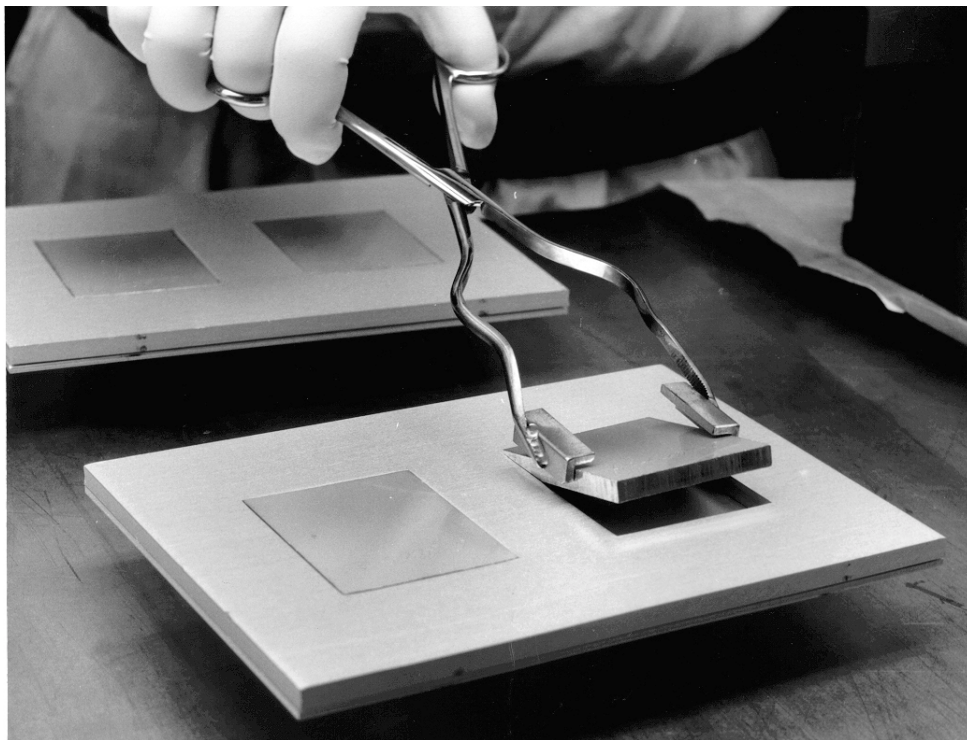


Fig. 10. Loading the frame using tongs.





Fig. 11. Clean area for loading frames.

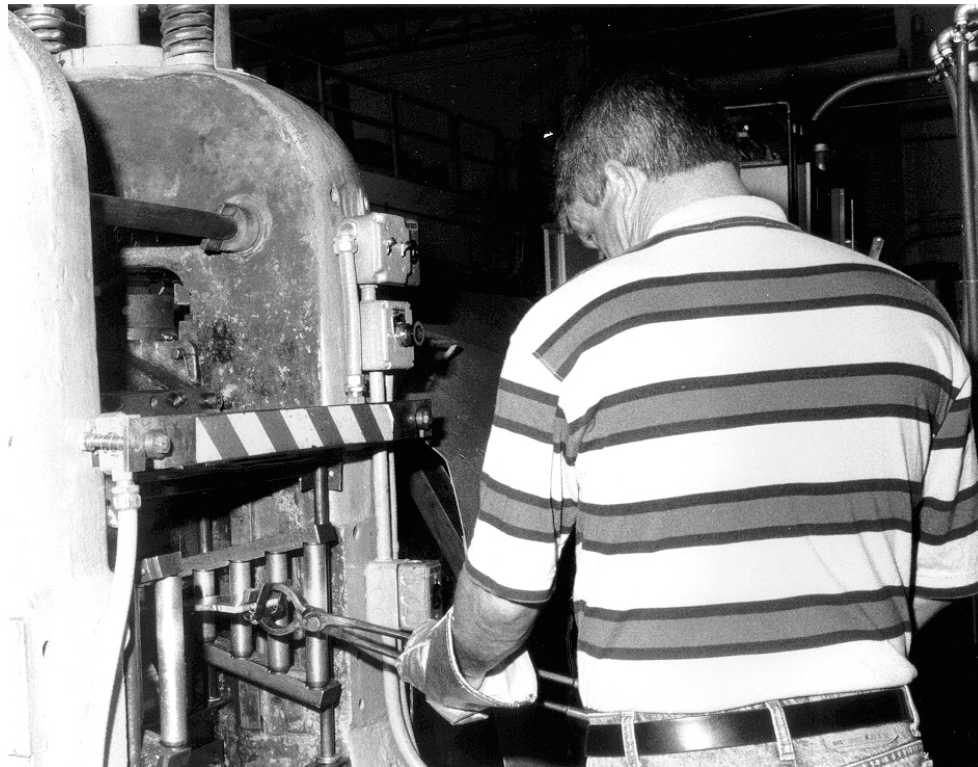


Fig. 12. Hot rolling fuel plates.

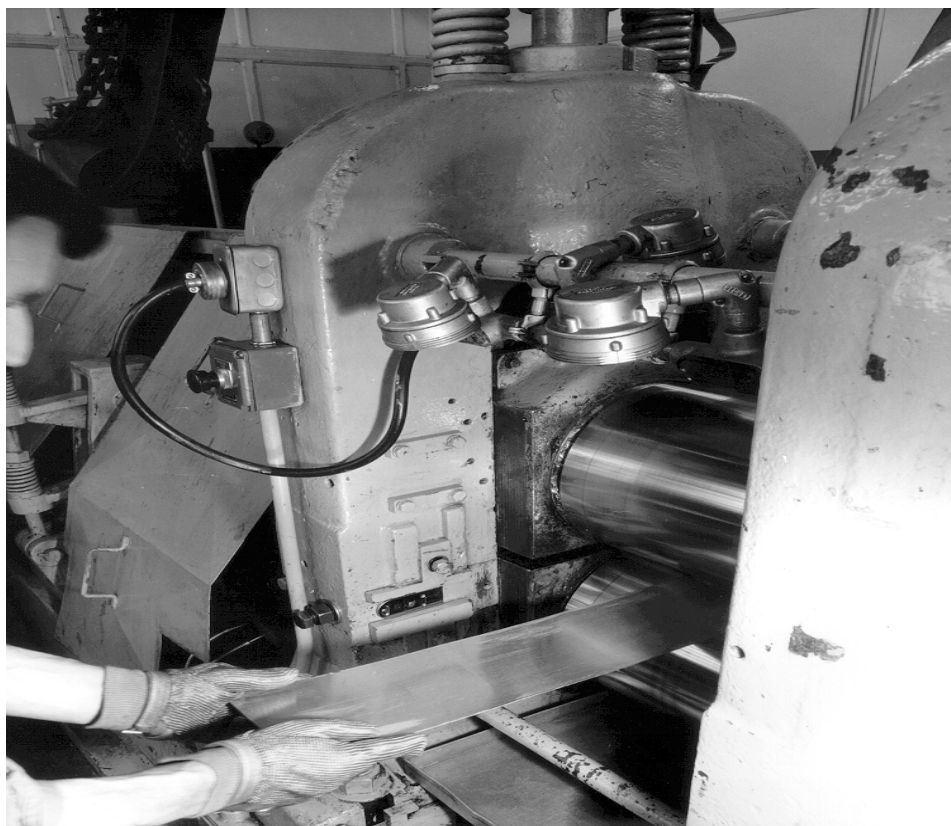


Fig. 13. Catching at the hot rolling mill.

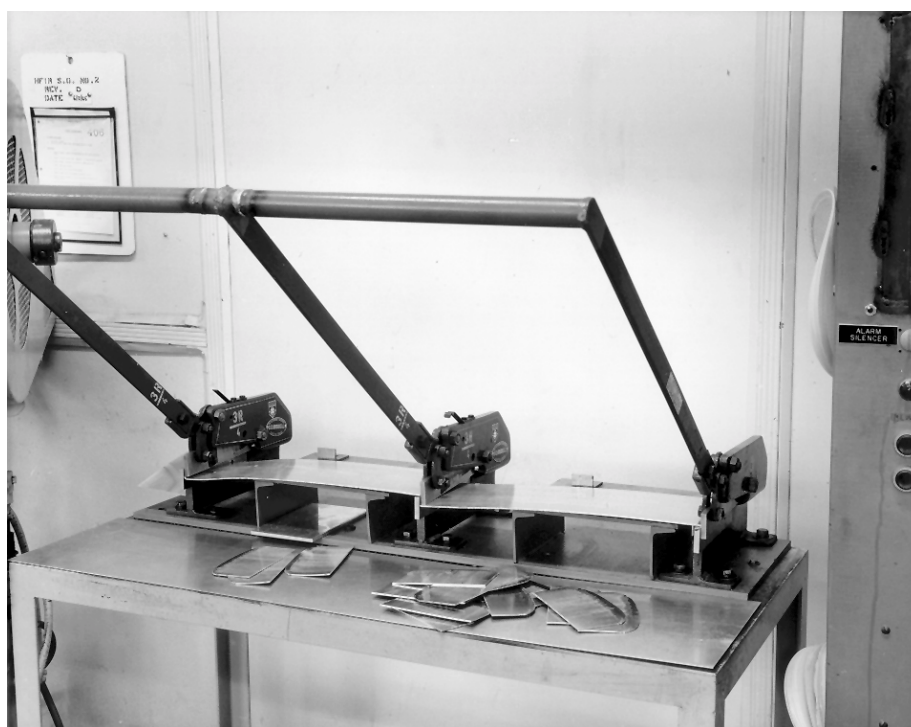


Fig. 14. Shear to separate fuel plates.





Figure 15. Fluoroscope

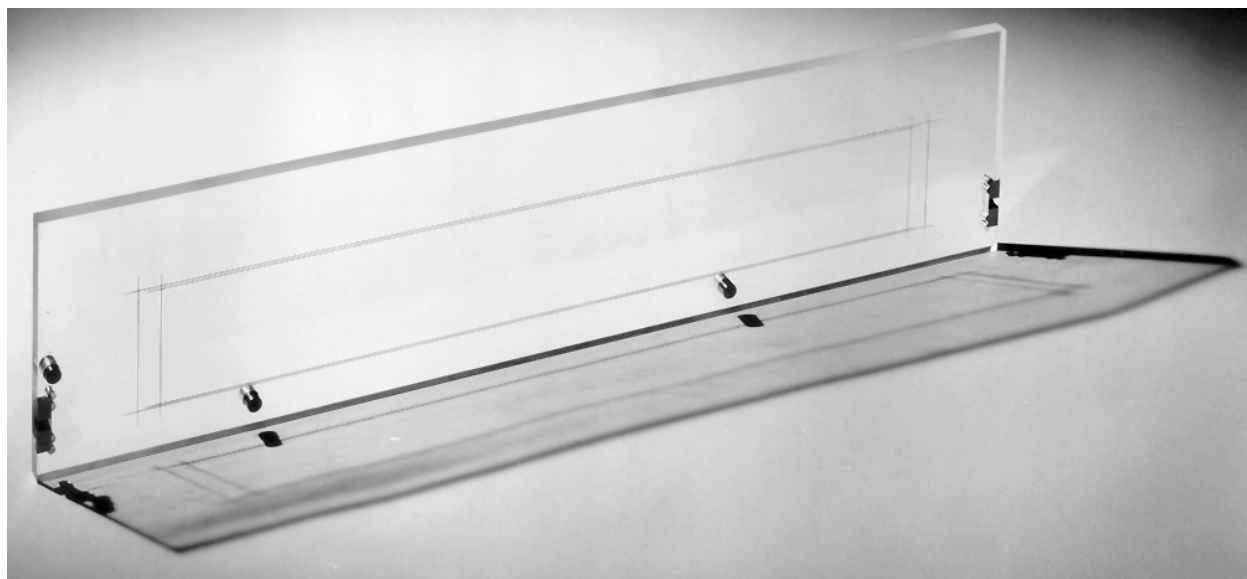


Fig. 16. Fluoroscope template showing maximum and minimum core outlines.

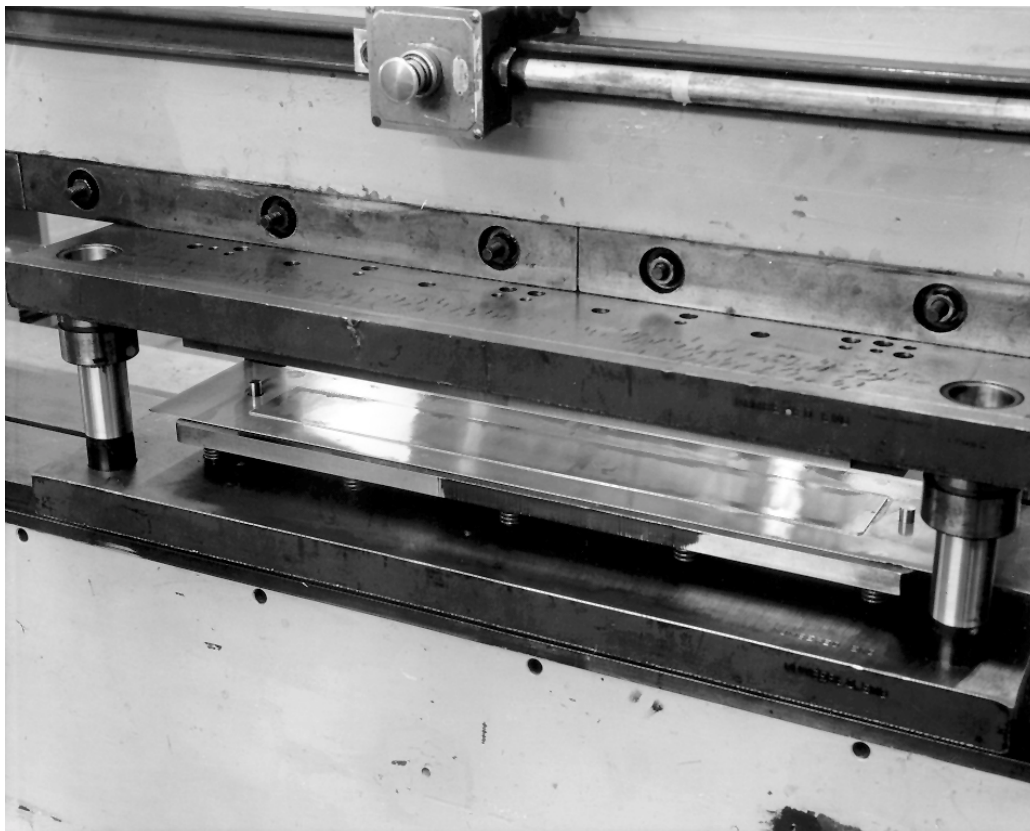


Fig. 17. Fuel plate blanking die.



Fig. 18. Forming die.